



The Likely Return of El Niño

Implications for the 2014 Arizona Monsoon Season & Beyond

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Topics For Today

- El Niño is forecast to make its triumphant return!
- Current conditions in the Equatorial Pacific Ocean
- Rainfall from a historical perspective
- 2014 AZ Monsoon and Cold Season rainfall outlooks



El Niño is Spanish for...“The Niño!”



- National Geographic Clip: <http://youtu.be/5gVe06xi9r4>
- NASA Clip: <http://youtu.be/VgYo1OGW0mE>



El Niño **WATCH** Issued This Spring

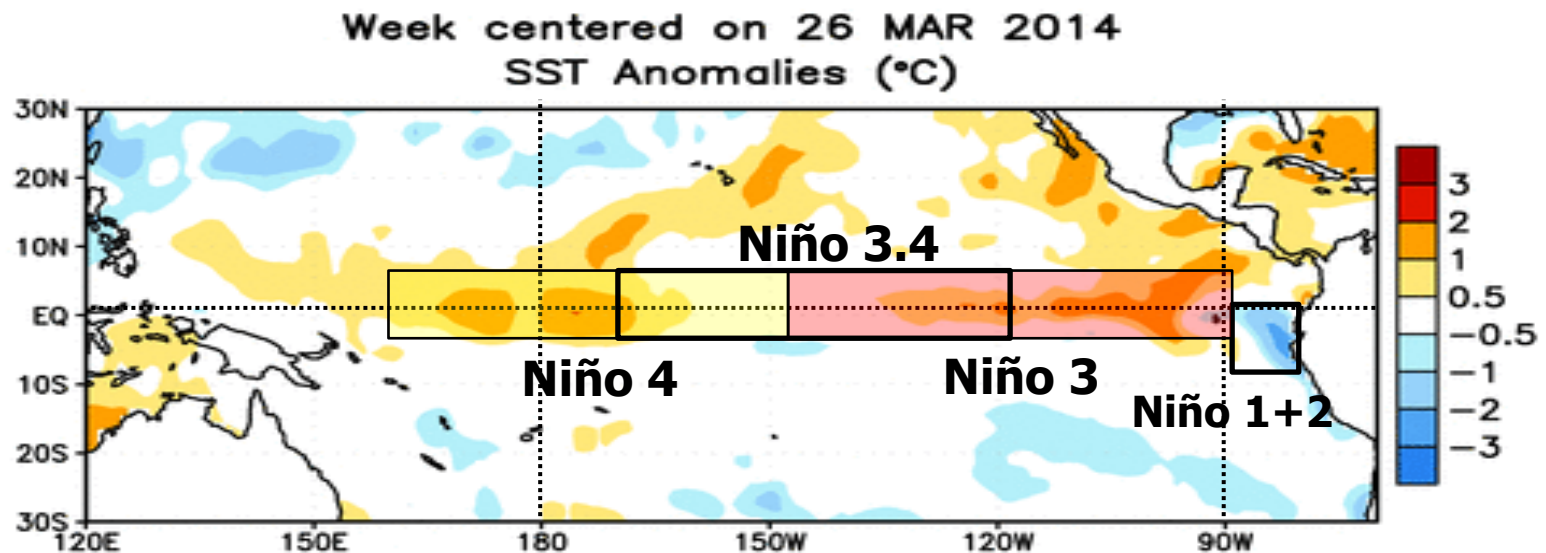
- An El Niño Watch is issued when conditions are favorable for the development of El Niño conditions within then next 6-months.

???




El Niño **WATCH** Issued This Spring

A 1-month positive SST anomaly of $>0.5^{\circ}\text{C}$ is observed in the Niño 3.4 region of the equatorial Pacific Ocean.



El Niño **WATCH** Issued This Spring

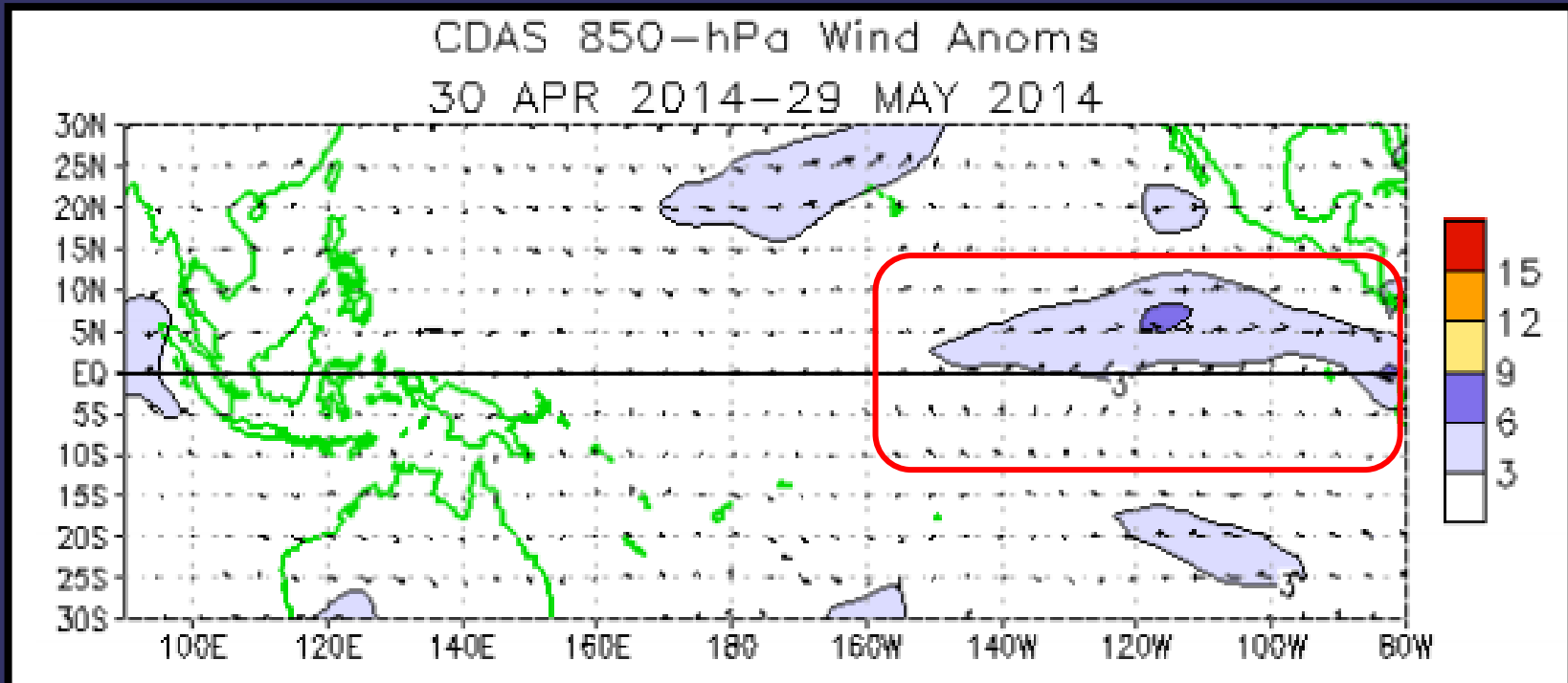
Expectation that the 3-month Oceanic Niño Index (ONI) threshold will be met

| Year | DJF | JFM | FMA | MAM | AMJ | MJJ | JJA | JAS | ASO | SON | OND | NDJ |
|------|------|------|------|------|------|--|------|------|------|------|------|------|
| 2009 | -0.8 | -0.7 | -0.5 | -0.2 | 0.2 | 0.4 | 0.5 | 0.6 | 0.8 | 1.1 | 1.4 | 1.6 |
| 2010 | 1.6 | 1.3 | 1.0 | 0.6 | 0.1 | -0.4 | -0.9 | -1.2 | -1.4 | -1.5 | -1.5 | -1.5 |
| 2011 | -1.4 | -1.2 | -0.9 | -0.6 | -0.3 | -0.2 | -0.2 | -0.4 | -0.6 | -0.8 | -1.0 | -1.0 |
| 2012 | -0.9 | -0.6 | -0.5 | -0.3 | -0.2 | 0.0 | 0.1 | 0.4 | 0.5 | 0.6 | 0.2 | -0.3 |
| 2013 | -0.6 | -0.6 | -0.4 | -0.2 | -0.2 | -0.3 | -0.3 | -0.3 | -0.3 | -0.2 | -0.3 | -0.4 |
| 2014 | -0.6 | -0.6 | -0.5 | -0.2 | ? |  | | | | | | |



El Niño **WATCH** Issued This Spring

An atmospheric response typically associated with El Niño is observed over the equatorial Pacific region



Current Observations

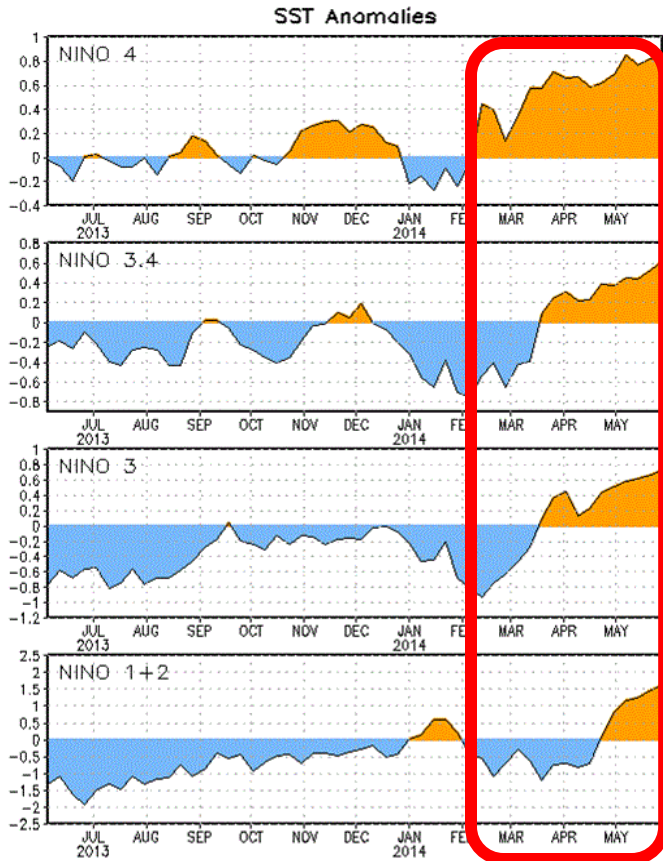


Figure 2. Time series of area-averaged sea surface temperature (SST) anomalies (°C) in the Niño regions [Niño-1+2 (0°-10°S, 90°W-80°W), Niño-3 (5°N-5°S, 150°W-90°W), Niño-3.4 (5°N-5°S, 170°W-120°W), Niño-4 (5°N-5°S, 150°W-160°E)]. SST anomalies are departures from the 1981-2010 base period weekly means.

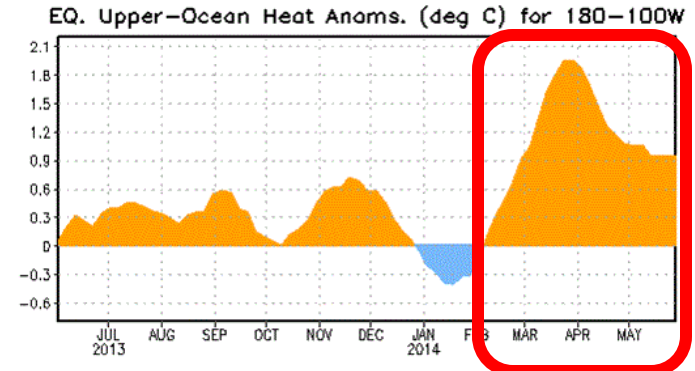


Figure 3. Area-averaged upper-ocean heat content anomaly (°C) in the equatorial Pacific (5°N-5°S, 180°-100°W). The heat content anomaly is computed as the departure from the 1981-2010 base period pentad means.

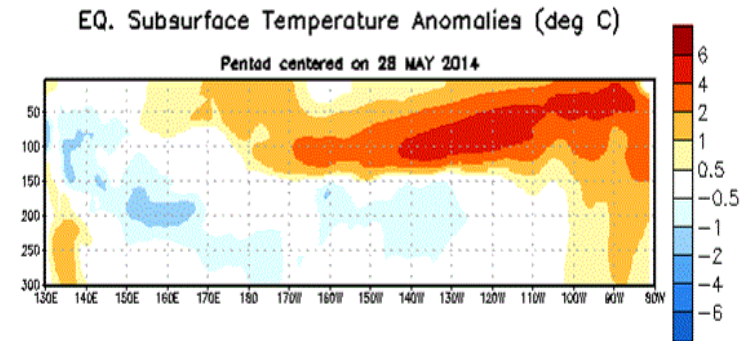
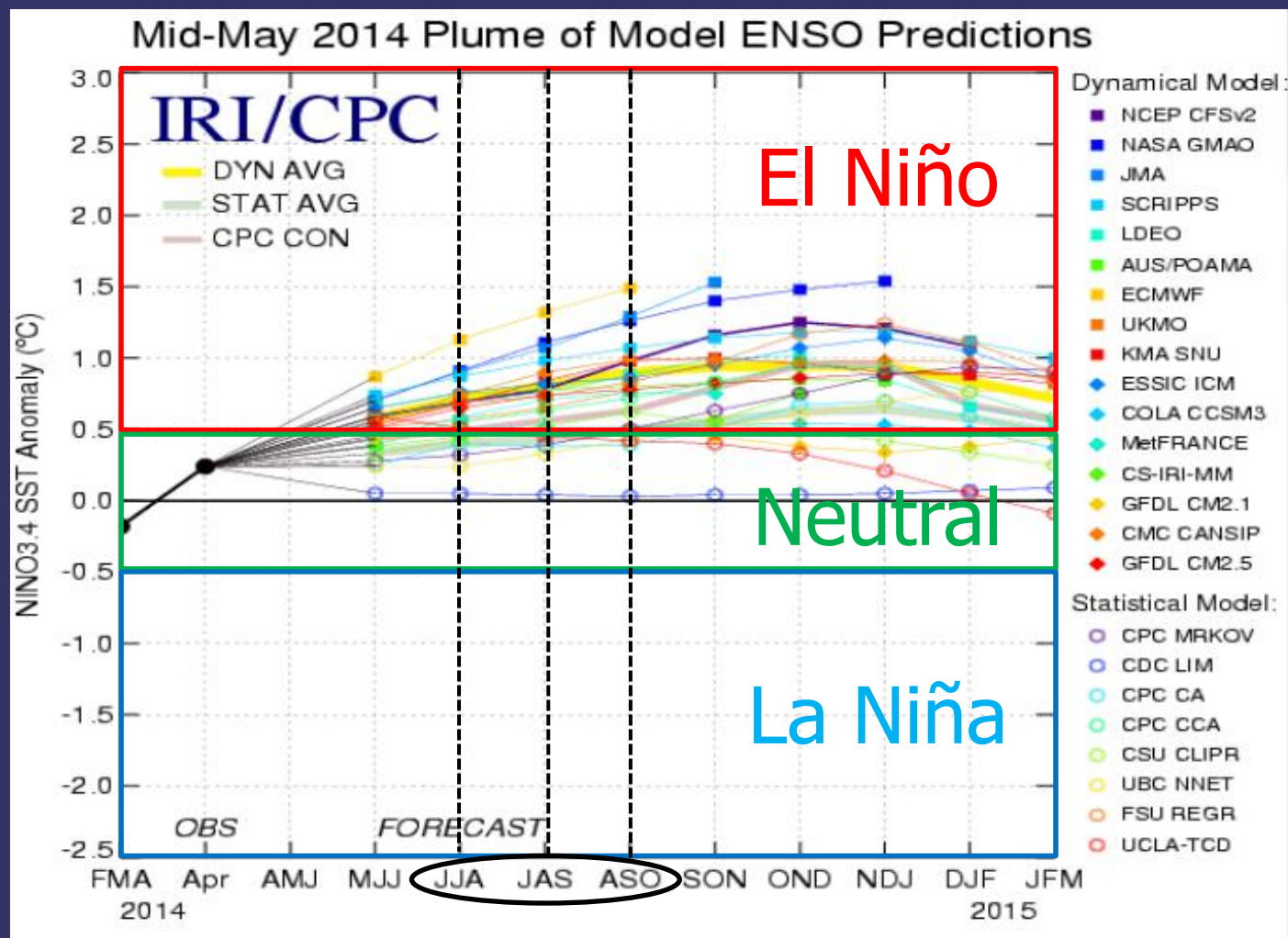


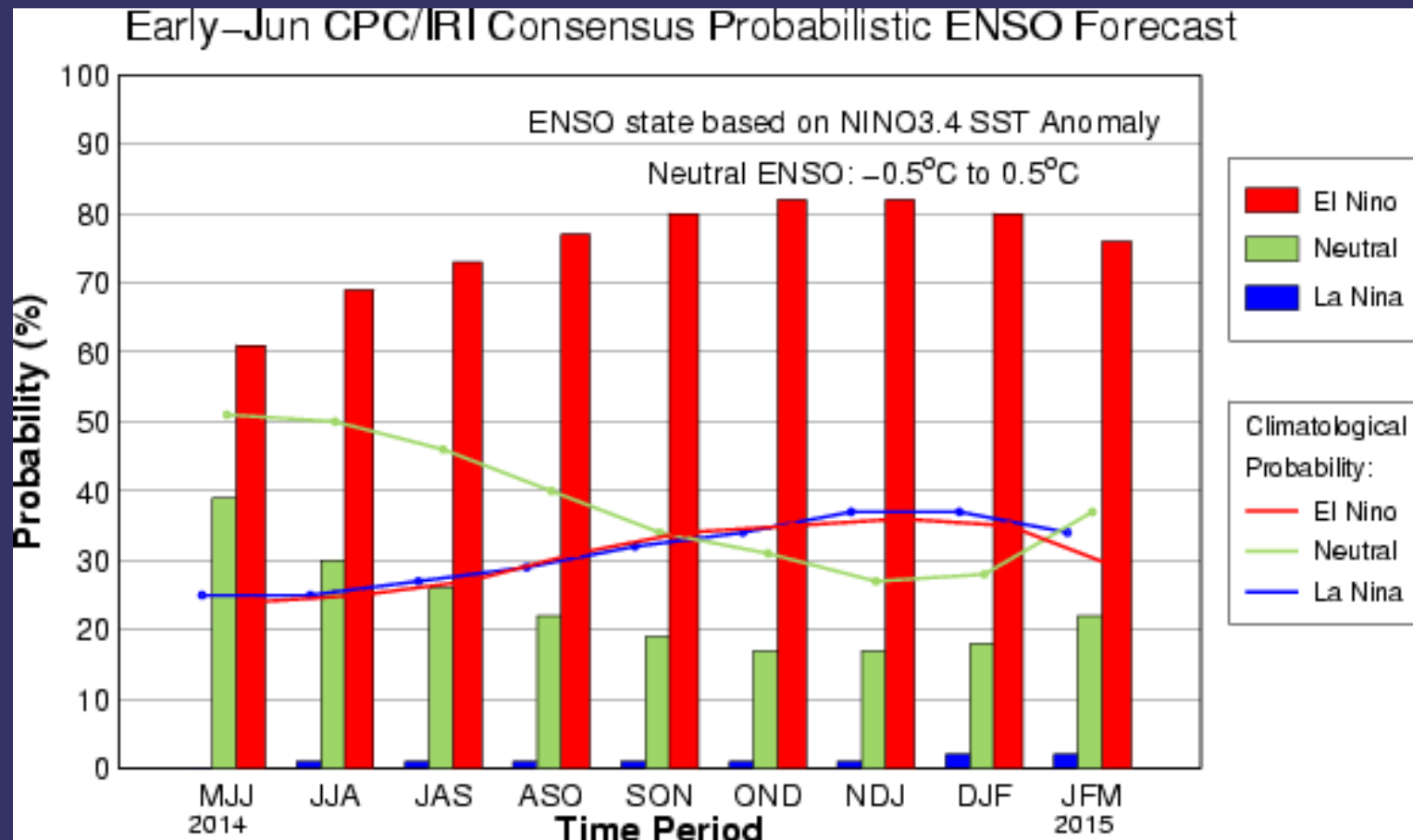
Figure 4. Depth-longitude section of equatorial Pacific upper-ocean (0-300m) temperature anomalies (°C) centered on the pentad of 28 May 2014. The anomalies are averaged between 5°N-5°S. Anomalies are departures from the 1981-2010 base period pentad means.



CPC ENSO Forecast



CPC ENSO Forecast



Strong Potential for an early onset to El Niño Conditions



Summary

- Current SST Anomalies in all Niño regions are greater than 0°C. Niño 3.4 Zone is currently $\approx 0.6^{\circ}\text{C}$
- Several periods during Jan-April with westerly wind bursts. More recently, developing low level westerly winds across eastern Pacific.
- Model Guidance suggesting more than five consecutive 3-month periods of SST Anomalies $> 0.5^{\circ}\text{C}$
- Increasing chances of El Niño development through the remainder of the year, exceeding 70% by early summer and 80% during the fall and winter.



What to Expect this Summer

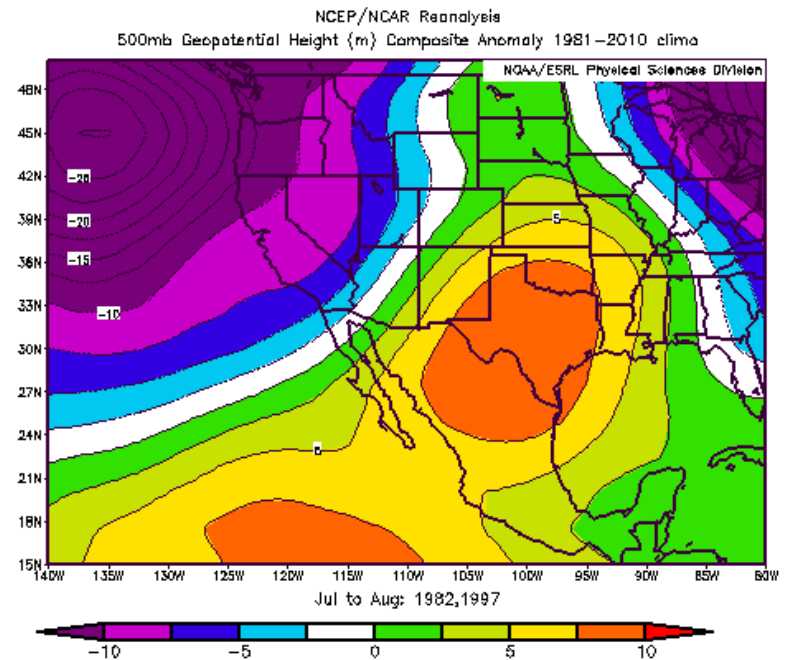
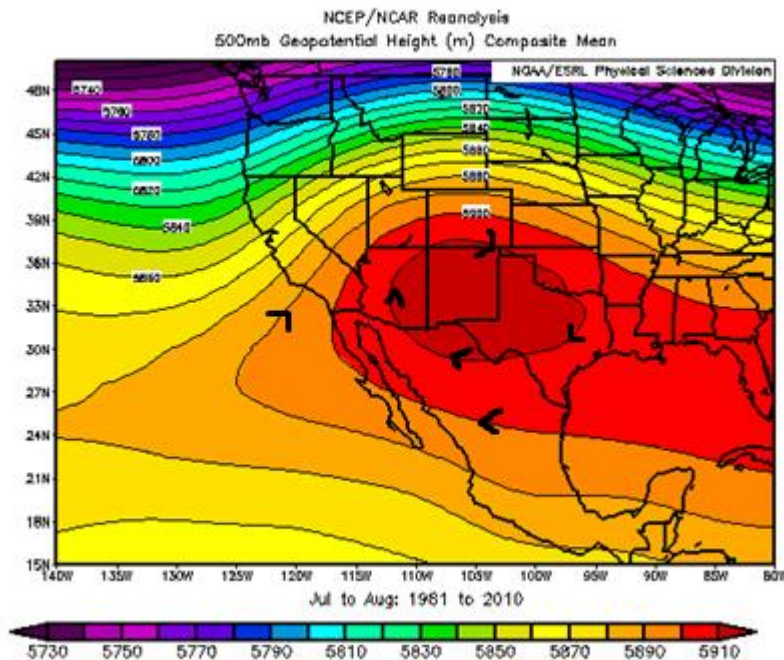
- El Niño climate signal is less noticeable during the summer months across the Desert Southwest, especially during the onset due to lag in atmospheric response.
- Increase in SSTs anomalies across Eastern Pacific and Gulf of California
- Monsoon Ridge (high pressure center), irregularities in general positioning and strength.
- Link with Active Eastern Pacific Hurricane Season:
 - El Niño decreases the vertical wind shear over the eastern tropical pacific making the atmosphere more conducive for hurricane development.



The Monsoon Ridge (July-August)

Climatology (1981-2010)

El Niño (1982, 1997)



Historical El Niño Episodes

Time Period: 1950-Present

16 episodes of El Niño were found in this study. Years where El Niño signal persisted through the following year were considered one event.

ONI Anomaly Strength (Lader, 2012)

Weak: 0.5°C – 0.9°C

Moderate: 1.0°C – 1.8°C









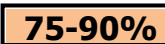
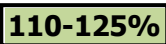





Strong: >1.8°C

El Niño Episodes since 1950

| Year | Strength | Start | Onset Timing |
|------|----------|-------|--------------------|
| 1951 | Weak | JJA | Summer |
| 1957 | Moderate | MAM | Spring |
| 1963 | Weak | MJJ | Late Spring/Summer |
| 1965 | Moderate | AMJ | Mid Spring |
| 1968 | Weak | JAS | Mid Summer |
| 1972 | Moderate | AMJ | Mid Spring |
| 1976 | Weak | ASO | Late Summer/Fall |
| 1982 | Strong | AMJ | Mid Spring |
| 1986 | Moderate | JAS | Mid Summer |
| 1991 | Moderate | AMJ | Mid Spring |
| 1994 | Moderate | ASO | Late Summer/Fall |
| 1997 | Strong | AMJ | Mid Spring |
| 2002 | Moderate | AMJ | Mid Spring |
| 2004 | Weak | JJA | Summer |
| 2006 | Weak | ASO | Late Summer/Fall |
| 2009 | Moderate | JJA | Summer |



Historical Monsoon Rainfall

| June 15th - Sept 30th Rainfall, Onset Year El Niño Episode | | | | | | |
|--|---|--------------------|---|----------------------|---|-------------|
| | Phoenix | Tucson | Yuma | Flagstaff *** | El Paso | Albuquerque |
| Onset Year | 2.71" | 6.08" | 1.29" | 7.93" | 5.14" | 4.12" |
| 1951  | 6.96" | 4.49" | 1.68" | 10.57" | 3.24" | 3.12" |
| 1957 | 1.57" | 5.26" | 1.03" | 4.81" | 6.87" | 3.80" |
| 1963 | 2.71" | 5.97" | 2.58" | 6.07" | 2.19" | 5.06" |
| 1965  | 1.85" | 4.07" | 0.05" | 8.50" | 2.97" | 3.95" |
| 1968  | 2.29" | 3.09" | 1.01" | 4.94" | 7.80" | 5.12" |
| 1972 | 3.84" | 8.01" | 0.27" | 7.46" | 5.11" | 5.25" |
| 1976  | 3.38" | 3.19" | 0.56" | 5.56" | 5.13" | 3.10" |
| 1982 | 2.52" | 7.46" | 1.32" | 7.38" | 6.94" | 3.84" |
| 1986 | 2.94" | 5.70" | 0.89" | 20.64" | 7.23" | 6.84" |
| 1991 | 1.07" | 4.15" | 0.60" | 3.53" | 6.58" | 5.34" |
| 1994 | 2.01" | 2.58" | 1.50" | | 0.23" | 4.80" |
| 1997  | 2.01" | 4.26" | 5.14" | 6.90" | 4.14" | 6.58" |
| 2002 | 1.68" | 5.79" | Trace | 7.61" | 2.75" | 4.11" |
| 2004  | 1.10" | 2.42" | Trace | 7.96" | 6.56" | 4.06" |
| 2006  | 3.33" | 10.20" | 0.24" | 8.79" | 15.28" | 9.42" |
| 2009 | 0.87" | 2.86" | 1.76" | 2.87" | 5.82" | 3.96" |
| POR Average |  | Below Normal |  | Above Normal |  | |
| Normal |  | Well Below Normal |  | Well Above Normal |  | |
| Missing |  | AZ Tropical System |  | June 1-Sept 30 Total | *** | |




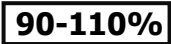
Historical Monsoon Rainfall


| June 15th - Sept 30th Rainfall, Onset Year El Niño Episode | | | | | | |
|--|---------|--------|-------|---------------|---------|-------------|
| | Phoenix | Tucson | Yuma | Flagstaff *** | El Paso | Albuquerque |
| Onset Year | 2.71" | 6.08" | 1.29" | 7.93" | 5.14" | 4.12" |
| 1951 | 6.96" | 4.49" | 1.68" | 10.57" | 3.24" | 3.12" |
| 1957 | 1.57" | 5.26" | 1.03" | 4.81" | 6.87" | 3.80" |
| 1963 | 2.71" | 5.97" | 2.58" | 6.07" | 2.19" | 5.06" |
| 1965 | 1.85" | 4.07" | 0.05" | 8.50" | 2.97" | 3.95" |
| 1968 | 2.29" | 5.89" | 4.85" | 4.94" | 5.12" | 3.10" |
| 1972 | 3.84" | 7.15" | 6.24" | 7.46" | 6.94" | 4.84" |
| 1976 | 3.38" | 3.19" | 0.56" | 5.56" | 7.23" | 6.84" |
| 1982 | 2.52" | 7.15" | 7.2" | 7.38" | 0.23" | 4.80" |
| 1986 | 2.94" | 5.70" | 0.89" | 20.64" | 4.14" | 6.58" |
| 1991 | 1.07" | 2.58" | 1.50" | 3.53" | 2.75" | 4.11" |
| 1994 | 2.01" | 2.58" | 1.50" | | 6.56" | 4.06" |
| 1997 | 2.01" | 4.26" | 5.14" | 6.90" | 15.28" | 9.42" |
| 2002 | 1.68" | 5.79" | Trace | 7.61" | 5.82" | 3.96" |
| 2004 | 1.10" | 2.42" | Trace | 7.96" | | |
| 2006 | 3.33" | 10.20" | 0.24" | 8.79" | | |
| 2009 | 0.87" | 2.86" | 1.76" | 2.87" | | |

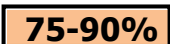
DRIER THAN AVERAGE


WETTER THAN AVERAGE


POR Average 

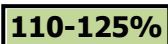
Normal  **90-110%**


Missing 

Below Normal  **75-90%**

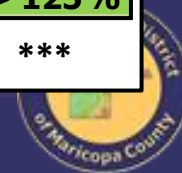
Well Below Normal  **< 75%**

AZ Tropical System 

Above Normal  **110-125%**

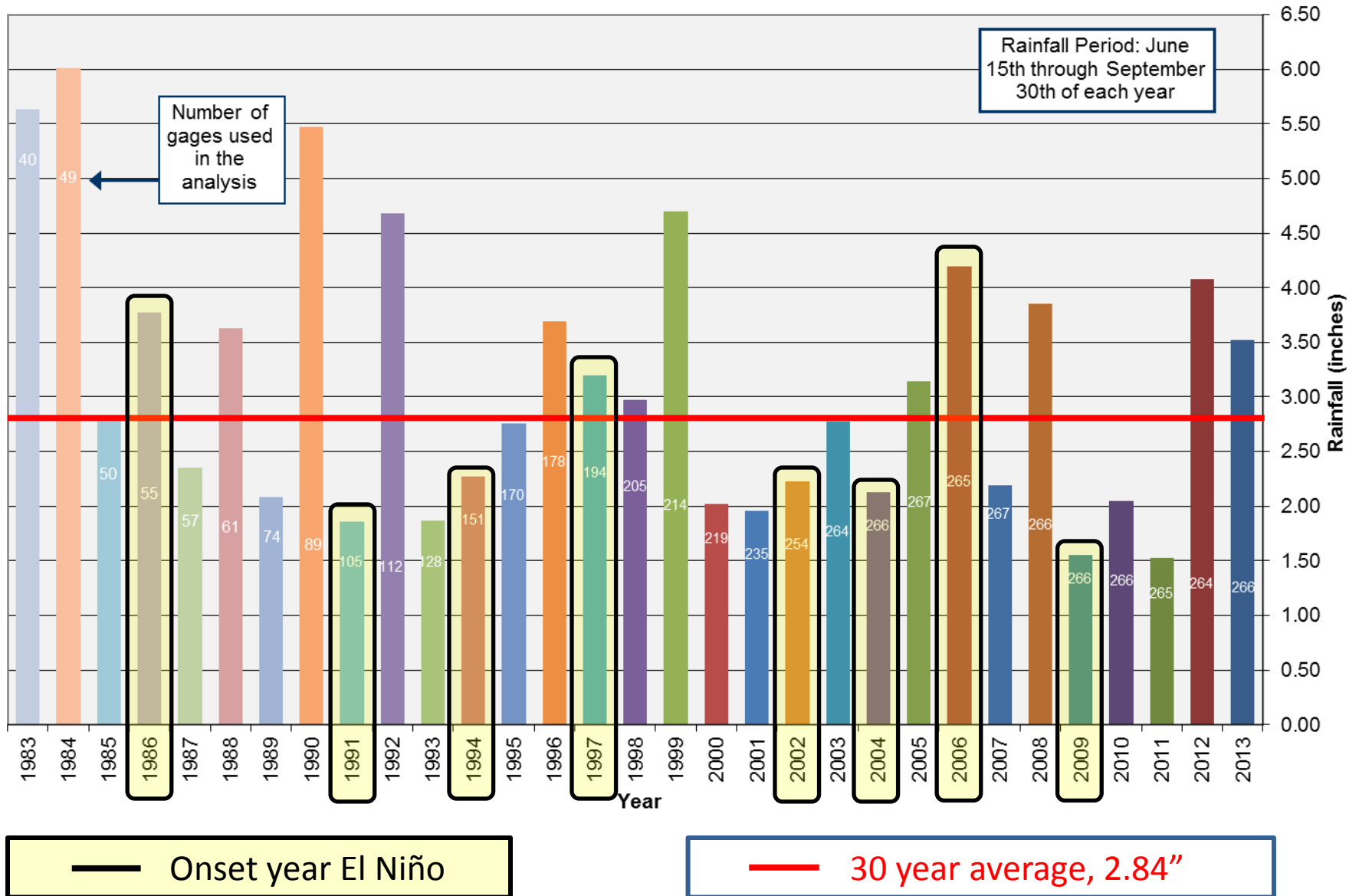
Well Above Normal  **> 125%**

June 1-Sept 30 Total ***



Average Summer Thunderstorm Season Rainfall

Flood Control District of Maricopa County ALERT Rain Gages



Summary

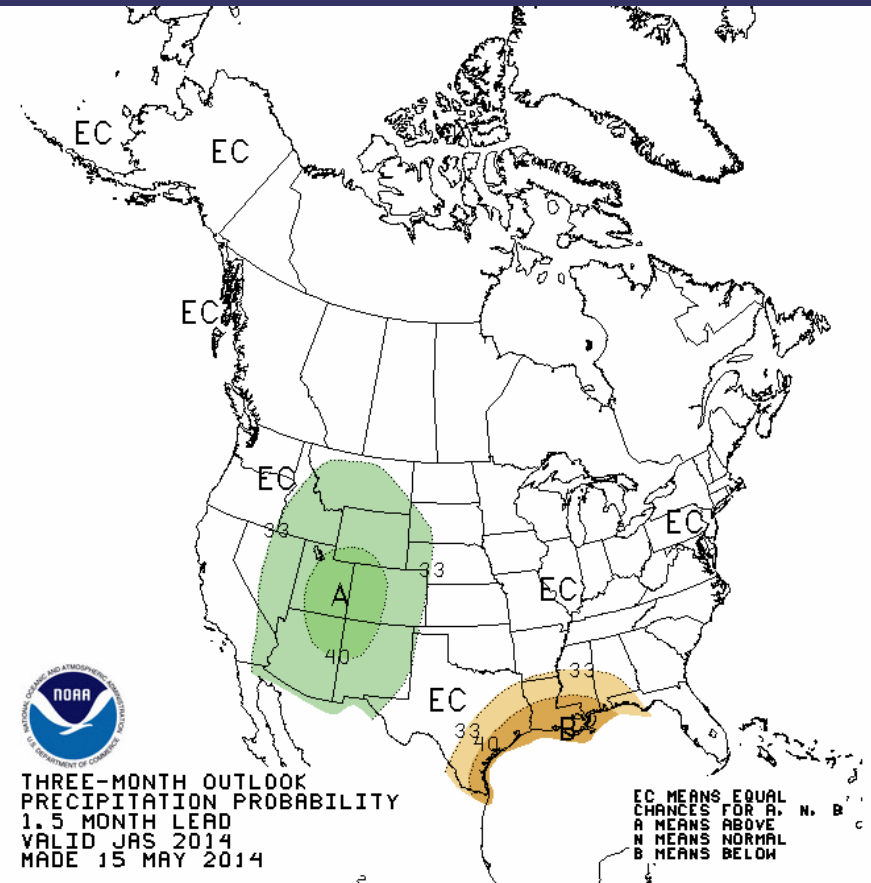
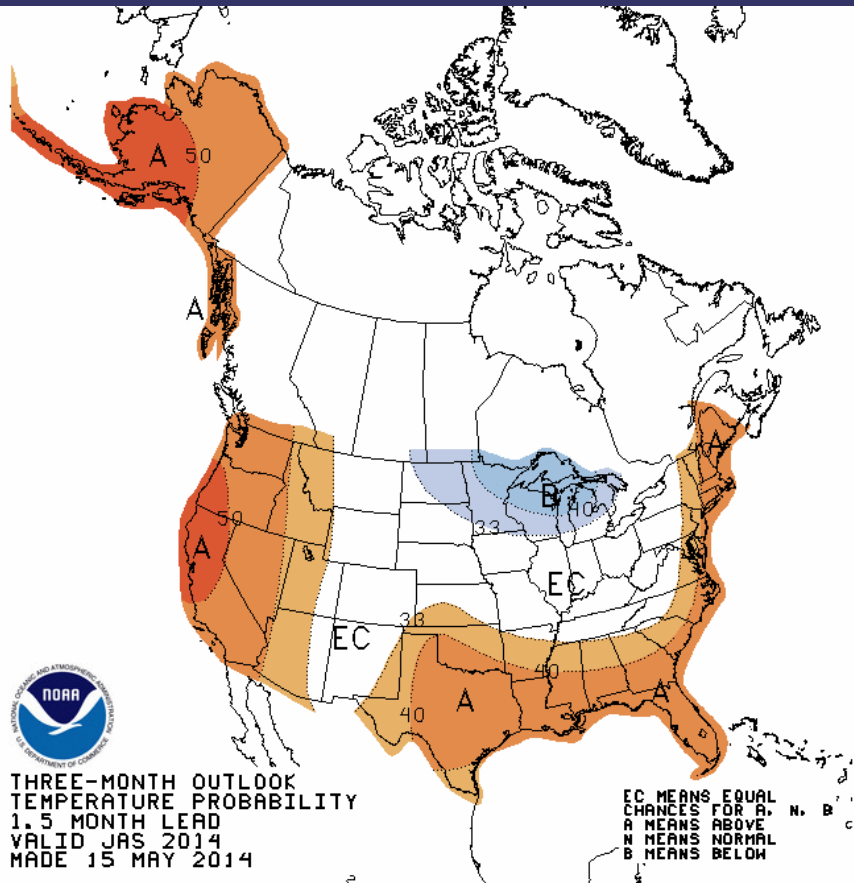
| Monsoon Rainfall, Percent of Normal During Onset of El Niño | | | | | | |
|---|-------------|-------------------|---------|--------|--------|-----------|
| El Niño Episodes | | Maricopa County * | Phoenix | Tucson | Yuma | Flagstaff |
| Strength | # of Events | 2.84 | 2.71 | 6.08 | 1.29 | 7.93 |
| Weak | 6 | 111.1% | 121.6% | 80.5% | 78.4% | 92.2% |
| Moderate | 8 | 73.9% | 73.0% | 79.0% | 59.1% | 99.8% |
| Strong | 2 | 105.7% | 83.6% | 96.4% | 250.4% | 90.0% |
| All Episodes | 16 | 87.2% | 92.6% | 81.7% | 90.3% | 95.5% |

* Maricopa Count Rainfall: 8 total El Niño Episodes (2 Weak, 5 Moderate, 1 Strong)

- Normal to below normal rainfall for each AZ location during the Monsoon season when averaged across all El Niño episodes.
- Tropical systems/remnants moving through AZ late season dirty the climate signal i.e. 1951, 1997, 2006.
- Below average rainfall does not mean a reduced flooding threat. El Niño has no effect on the strength of Monsoon t-storms. All the hazards associated with Monsoon Season still present.



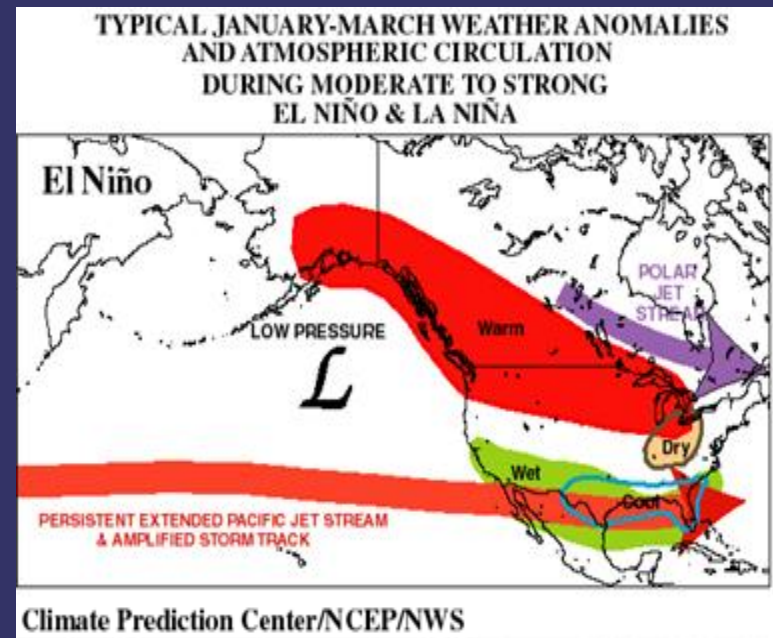
CPC 3-month Outlook (July-August-September)



Fall/Winter Seasons

Typically, the El Niño Climate signal is more evident during the winter months across U.S.

- Large Scale Impacts:
 - Persistent and extended Pacific Jet Stream.
 - Southward shift of storm track.
 - Cyclone genesis area amplified west of CA as opposed to Pac-NW.
 - Wet/Cool across Southern US & Dry/mild across northern US.



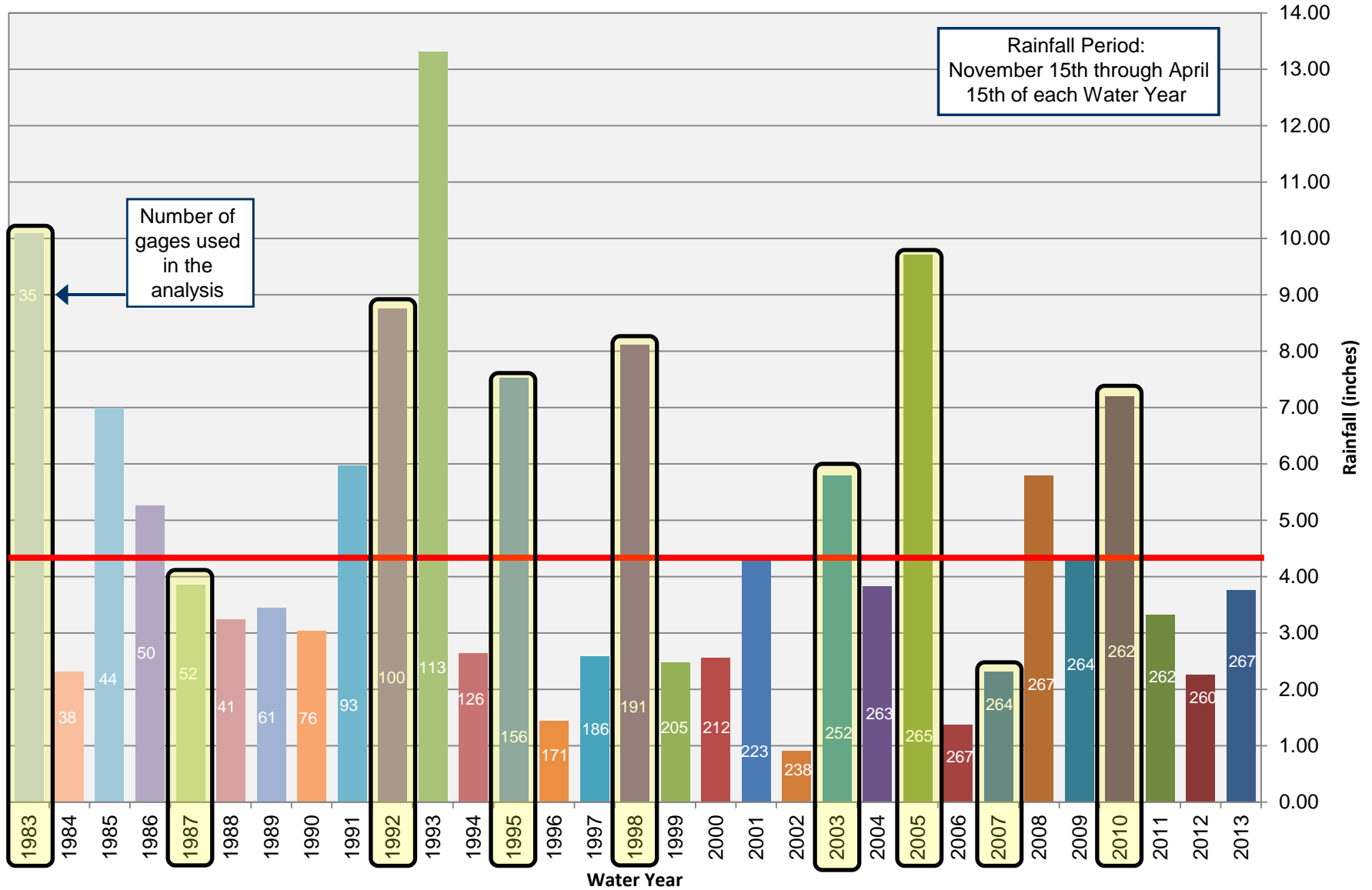
Historical "Cold Season" Rainfall

| November - April Rainfall, Following El Niño Onset | | | | | | |
|--|---------|-------------------|--------|-----------|-------------------|-------------|
| | Phoenix | Tucson | Yuma | Flagstaff | El Paso | Albuquerque |
| Following Onset | 4.15" | 4.19" | 1.76" | 10.66" | 2.35" | 2.65" |
| 1951-1952 | 6.30" | 6.35" | 1.77" | 15.67" | 3.78" | 2.14" |
| 1957-1958 | 4.30" | 4.90" | 2.22" | 12.30" | 4.92" | 4.37" |
| 1963-1964 | 1.43" | 3.09" | 1.11" | 8.21" | 1.83" | 2.22" |
| 1965-1966 | 5.75" | 10.09" | 2.89" | 14.98" | 2.52" | 2.51" |
| 1968-1969 | 4.34" | 4.36" | 0.87" | 15.23" | 1.88" | 4.00" |
| 1972-1973 | 5.82" | 5.79" | 1.73" | 19.44" | 4.27" | 5.32" |
| 1976-1977 | 2.02" | 3.99" | 1.11" | 5.98" | 2.35" | 3.15" |
| 1982-1983 | 9.36" | 6.95" | 3.88" | 20.22" | 5.72" | 3.82" |
| 1986-1987 | 4.51" | 5.56" | 0.74" | 10.06" | 4.24" | 4.07" |
| 1991-1992 | 8.38" | 7.56" | 3.49" | 18.10" | 5.89" | 5.07" |
| 1994-1995 | 6.79" | 9.09" | 1.80" | 14.98" | 3.75" | 3.79" |
| 1997-1998 | 5.91" | 8.77" | 4.35" | 11.36" | 2.62" | 5.51" |
| 2002-2003 | 4.98" | 2.52" | 1.21" | 6.63" | 3.22" | 3.32" |
| 2004-2005 | 7.42" | 4.07" | 3.96" | 23.12" | 5.17" | 7.12" |
| 2006-2007 | 2.27" | 2.11" | 0.06" | 3.57" | 2.44" | 4.10" |
| 2009-2010 | 5.40" | 5.17" | 3.80" | 13.02" | 4.04" | 1.98" |
| POR Average | | | | | | |
| Normal | 90-110% | | | | | |
| | | Below Normal | 75-90% | | Above Normal | 110-125% |
| | | Well Below Normal | < 75% | | Well Above Normal | > 125% |



Average Cold Season Rainfall

Flood Control District of Maricopa County ALERT Rain Gages



— Winter following El Niño Onset

— 30 year average, 4.40"

SUMMARY

| Cold Season Rainfall, Percent of Normal After Onset of El Niño | | | | | | |
|---|-------------|-------------------|---------|--------|--------|-----------|
| El Niño Episodes | | Maricopa County * | Phoenix | Tucson | Yuma | Flagstaff |
| Strength | # of Events | 2.84 | 2.71 | 6.08 | 1.29 | 7.93 |
| Weak | 6 | 137.9% | 95.5% | 96.9% | 84.1% | 112.2% |
| Moderate | 8 | 146.1% | 138.3% | 151.2% | 127.0% | 128.4% |
| Strong | 2 | 182.5% | 184.0% | 187.6% | 233.8% | 148.1% |
| All Episodes | 16 | 152.4% | 128.0% | 135.4% | 124.3% | 124.8% |
| * Maricopa County Rainfall: 9 total El Niño Episodes (2 Weak, 5 Moderate, 2 Strong) | | | | | | |

- Well Above Normal rainfall for all locations following the onset of Moderate/Strong El Niño with few exceptions.
- Weak El Niño + late Onset (1963, 1976, 2006): Well below normal rainfall County/Phoenix. Below normal for AZ. Less of an impact on areas east.
- El Niño helps create a favorable large scale pattern with increased frequency of passing disturbances.



CPC 3-month Outlooks (Fall/Winter 2014-2015)

Forecast Calling For:

- Increased chances for above average rainfall predicted throughout the Cold Season (Nov-April).
- Highest probabilities of above avg. rainfall shift east as we transition into 2015. This mimics continuation/progression of El Niño pattern.

Oct-Nov-Dec



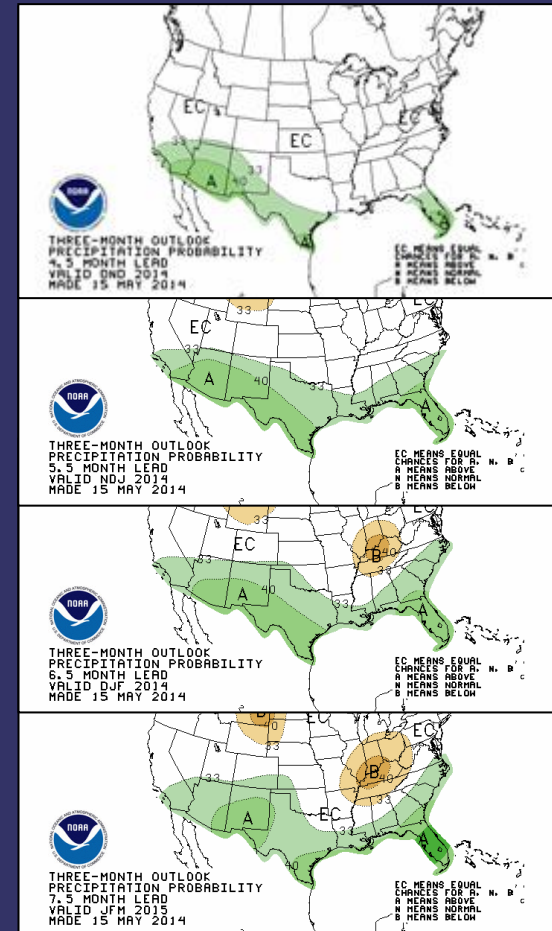
Nov-Dec-Jan



Dec-Jan-Feb



Jan-Feb-Mar



Final Thoughts

- All observational and model data is pointing towards the return of El Niño, but it is still a wait and see scenario...
- ENSO is one of many large scale features that come into play when making long term predictions. Many more complex smaller scale features/interactions that figure into making exact predictions.
- El Nino climate signal much weaker in summer than winter, meaning more variability in predictions due to other drivers

Fearless Forecast: Moderate El Niño lasting into 2015

2014 AZ Monsoon Season: 90% of avg. rainfall, ≈ 2.50" *

2014-2015 AZ Cold Season: 150% of avg. rainfall, ≈ 6.50" *

* Rainfall forecasts above are averaged totals across all Maricopa County ALERT gages *

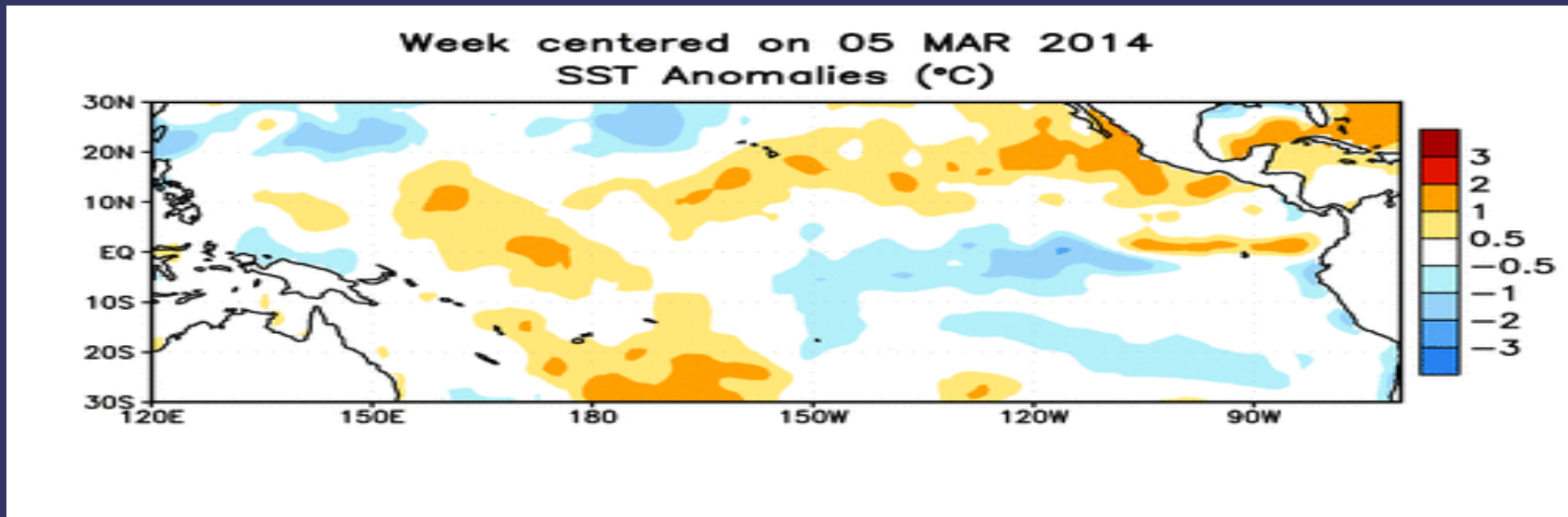


Data Sources/References

- El Niño observational and forecast images, Climate Prediction Center:
<http://www.cpc.ncep.noaa.gov/>
- Historic Monsoon rainfall data, NWS Tucson WFO:
http://www.wrh.noaa.gov/twc/monsoon/monsoon_tracker.php
- Historic monthly rainfall data, NOAA/NWS, NOWData:
<http://www.sercc.com/nowdata>
- Historic ALERT rainfall data, Flood Control District of Maricopa County:
<http://www.fcd.maricopa.gov/Rainfall/rainfall.aspx>
- *El Nino and La Nina Episodes and Their Impact on the Weather in the Tucson Metropolitan Area*: Glenn Lader, WFO Tucson, AZ, 2012:
<http://www.wrh.noaa.gov/wrh/talite1201.pdf>



Questions...?



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